## CLAIMS

1. Steel plate for ultra-high-strength linepipe having excellent low-temperature toughness consisting of:

C : 0.03 to 0.07 mass%

5 Si : not more than 0.6 mass%

Mn : 1.5 to 2.5 mass%

P : not more than 0.015 mass%

s : not more than 0.003 mass%

Mo : 0.15 to 0.60 mass%

10 Nb : 0.01 to 0.10 mass%

Ti : 0.005 to 0.030 mass%

Al : not more than 0.10 mass%

and, one or more of:

Ni : 0.1 to 1.5 mass%

15 B : less than 3 ppm

V : not more than 0.10 mass%

Cu : not more than 1.0 mass%

Cr : not more than 1.0 mass%

Ca : not more than 0.01 mass%

20 REM : not more than 0.02 mass%

Mg : not more than 0.006 mass%

and the remainder consisting of iron and unavoidable impurities and having the value P defined below being between 2.5 and 4.0, in which;

the ratio  $(Hv-ave_p)/(Hv-M)$  between the average Vickers hardness  $Hv-ave_p$  in the direction of thickness and the martensitic hardness Hv-M determined by carbon content is between 0.8 and 0.9, and the transverse tensile strength  $TS-T_p$  is between 880 MPa and 1080 MPa,

30 
$$P = 2.7C + 0.4Si + Mn + 0.8Cr + 0.45(Ni + Cu) + Mo - 1$$

Hv-M = 270 + 1300C

wherein the symbols of elements designate the mass% of the individual elements.

35 2. Steel plate for ultra-high-strength linepipe having excellent low-temperature toughness consisting of:

C : 0.03 to 0.07 mass%

Si • : not more than 0.6 mass% : 1.5 to 2.5 mass% Mn Ρ : not more than 0.015 mass% S : not more than 0.003 mass% 5 Мо : 0.15 to 0.60 mass% : 0.01 to 0.10 mass% Nb Тi : 0.005 to 0.030 mass% Al : not more than 0.10 mass% В : 3 ppm to 0.0025 mass% 10 and, one or more of: Νi : 0.1 to 1.5 mass% N : 0.001 to 0.006 mass% V : not more than 0.10 mass% : not more than 1.0 mass% Cu 15 Cr : not more than 1.0 mass% Ca : not more than 0.01 mass% REM : not more than 0.02 mass% Ma : not more than 0.006 mass% and the remainder consisting of iron and unavoidable 20 impurities and having the value P defined below being between 2.5 and 4.0, in which; the ratio  $(Hv-ave_p)/(Hv-M)$  between the average Vickers hardness Hv-ave, in the direction of thickness and the martensitic hardness Hv-M determined by carbon content is 25 between 0.8 and 0.9, and the transverse tensile strength TS-Tp is between 880 MPa and 1080 MPa, P = 2.7C + 0.4Si + Mn + 0.8Cr + 0.45(Ni + Cu) +2Mo

Hv-M = 270 + 1300C

30

wherein the symbols of elements designate the mass% of the individual elements.

- 3. Steel plate for ultra-high-strength linepipe having excellent low-temperature toughness described in claim 1 or 2, containing:
- 35 N : 0.001 to 0.006 mass%.
  - 4. Steel plate for ultra-high-strength linepipe having excellent low-temperature toughness described in

claim 3, in which the relationship Ti - 3.4 N > 0 is satisfied (wherein the symbols of elements designate the mass% of the individual elements).

- 5. Steel plate for ultra-high-strength linepipe having excellent low-temperature toughness described in any of claims 1 to 4, in which the V-notch Charpy value at -20 °C is not lower than 200J.
- 6. Steel plate for ultra-high-strength linepipe having excellent low-temperature toughness described in any of claims 1 to 5, in which the longitudinal tensile strength  $TS-L_p$  is not greater than 0.95 times the transverse tensile strength  $TS-T_p$ .
- 7. Steel plate for ultra-high-strength linepipe having excellent low-temperature toughness described in any of claims 1 to 6, in which the yield ratio in the direction of rolling (YS  $L_p$ )/(TS  $L_p$ ), which is the ratio of the 0.2% offset yield strength YS  $L_p$  in the direction of rolling to the tensile strength TS  $L_p$  in the direction of rolling is not greater than 0.8.
- 8. Ultra-high-strength linepipe having excellent low-temperature toughness prepared by seam-welding steel plate consisting of:

C : 0.03 to 0.07 mass%

Si : not more than 0.6 mass%

25 Mn : 1.5 to 2.5 mass%

5

10

15

30

35

P : not more than 0.015 mass%

s : not more than 0.003 mass%

Ni : 0.1 to 1.5 mass%

Mo : 0.15 to 0.60 mass%

Nb : 0.01 to 0.10 mass%

Ti : 0.005 to 0.030 mass%

Al : not more than 0.06 mass%

and, one or more of:

B : not more than 0.0025 mass%

N : 0.001 to 0.006 mass%

V : not more than 0.10 mass%

Cu : not more than 1.0 mass%

Cr · : not more than 1.0 mass%

Ca : not more than 0.01 mass%

REM : not more than 0.02 mass%

Mg : not more than 0.006 mass%

and the remainder consisting of iron and unavoidable impurities and having the value P defined below being between 2.5 and 4.0, in which;

the ratio (Hv-ave)/(Hv-M) between the average Vickers hardness Hv-ave in the direction of thickness of the base metal and the martensitic hardness Hv-M determined by carbon content is between 0.8 and 0.9 and the circumferential tensile strength TS-C is between 900 MPa

$$P = 2.7C + 0.4Si + Mn + 0.8Cr + 0.45(Ni + Cu) + (1 + \beta) Mo - 1+\beta$$

where  $\beta$  = 1 when B  $\geq$  3 ppm and  $\beta$  = 0 when B < 3 ppm Hv-M = 270 + 1300C

wherein the symbols of elements designate the mass% of the individual elements.

9. Ultra-high-strength linepipe having excellent low-temperature toughness prepared by seam-welding steel plate consisting of:

C : 0.03 to 0.07 mass%

Si : not more than 0.6 mass%

25 Mn : 1.5 to 2.5 mass%

and 1100 MPa,

10

15

P : not more than 0.015 mass%

s : not more than 0.003 mass%

Mo : 0.15 to 0.60 mass%

Nb : 0.01 to 0.10 mass%

30 Ti : 0.005 to 0.030 mass%

Al : not more than 0.10 mass%

and, one or more of:

Ni : 0.1 to 1.5 mass%

B : less than 3 ppm

35 V : not more than 0.10 mass%

Cu : not more than 1.0 mass%

Cr : not more than 1.0 mass%

. Ca : not more than 0.01 mass% REM : not more than 0.02 mass%

Mg : not more than 0.006 mass%

and the remainder consisting of iron and unavoidable impurities and having the value P defined below being between 2.5 and 4.0, in which;

the ratio (Hv-ave)/(Hv-M\*) between the average Vickers hardness Hv-ave in the direction of thickness of the base metal and the martensitic hardness Hv-M\* determined by carbon content is between 0.75 and 0.9 and the circumferential tensile strength TS-C is between 900 MPa and 1100 MPa,

P = 2.7C + 0.4Si + Mn + 0.8Cr + 0.45(Ni + Cu) + Mo - 1

15 Hv-M\* = 290 + 1300C

5

10

20

wherein the symbols of elements designate the mass% of the individual elements.

10. Ultra-high-strength linepipe having excellent low-temperature toughness prepared by seam-welding steel plate consisting of:

C : 0.03 to 0.07 mass%

Si : not more than 0.6 mass%

Mn : 1.5 to 2.5 mass%

P : not more than 0.015 mass%

25 S : not more than 0.003 mass%

Mo : 0.15 to 0.60 mass%

Nb : 0.01 to 0.10 mass%

Ti : 0.005 to 0.030 mass%

Al : not more than 0.10 mass%

30 B : 3 ppm to 0.0025 mass%

and, one or more of:

Ni : 0.1 to 1.5 mass%

N : 0.001 to 0.006 mass%

V : not more than 0.10 mass%

35 Cu : not more than 1.0 mass%

Cr : not more than 1.0 mass%

Ca : not more than 0.01 mass%

REM': not more than 0.02 mass%

Mg : not more than 0.006 mass%

and the remainder consisting of iron and unavoidable impurities and having the value P defined below being between 2.5 and 4.0, in which;

the ratio  $(Hv-ave)/(Hv-M^*)$  between the average Vickers hardness Hv-ave in the direction of thickness of the base metal and the martensitic hardness  $Hv-M^*$  determined by carbon content is between 0.75 and 0.9 and the

10 circumferential tensile strength TS-C is between 900 MPa and 1100 MPa,

P = 2.7C + 0.4Si + Mn + 0.8Cr + 0.45(Ni + Cu) + 2Mo

Hv-M\* = 290 + 1300C

5

25

- wherein the symbols of elements designate the mass% of the individual elements.
  - 11. Ultra-high-strength linepipe having excellent low-temperature toughness described in claim 9 or 10 containing:
- 20 N : 0.001 to 0.006 mass%.
  - 12. Ultra-high-strength linepipe having excellent low-temperature toughness described in claim 11, in which the relationship  $Ti-3.4\ N>0$  is satisfied (wherein the symbols of elements designate the mass% of the individual elements).
  - 13. Ultra-high-strength linepipe having excellent low-temperature toughness described in any of claims 8 to 12, in which the V-notch Charpy value at -20 °C is not lower than 200J.
- 14. Ultra-high-strength linepipe having excellent low-temperature toughness described in any of claims 8 to 13, in which the tensile strength in the longitudinal direction of linepipe is not greater than 0.95 times the tensile strength in the circumferential direction thereof.
  - 15. A method for manufacturing steel plate for ultra-high-strength linepipe having excellent low-

temperature toughness comprising the steps of:

heating slabs consisting of:

C : 0.03 to 0.07 mass%

Si : not more than 0.6 mass%

5 Mn : 1.5 to 2.5 mass%

P : not more than 0.015 mass%

S : not more than 0.003 mass%

Mo : 0.15 to 0.60 mass%

Nb : 0.01 to 0.10 mass%

10 Ti : 0.005 to 0.030 mass%

Al : not more than 0.10 mass%

and, one or more of:

Ni : 0.1 to 1.5 mass%

B : less than 3 ppm

15 V : not more than 0.10 mass%

Cu : not more than 1.0 mass%

Cr : not more than 1.0 mass%

Ca : not more than 0.01 mass%

REM : not more than 0.02 mass%

20 Mg : not more than 0.006 mass%

25

30

and the remainder consisting of iron and unavoidable impurities and having the value P defined below being between 2.5 and 4.0 and between 1000 and 1250 °C,

rough rolling in a recrystallizing region,

rolling in an unrecrystallization austenitic region at 900 °C or below with a cumulative rolling reduction of not less than 75% and, then,

applying accelerated cooling from the austenitic region so that the center of plate thickness cools to 500 °C or below at a rate of 1 to 10 °C/sec.,

$$P = 2.7C + 0.4Si + Mn + 0.8Cr + 0.45(Ni + Cu) + Mo - 1$$

wherein the symbols of elements designate the mass% of the individual elements.

35 16. A method for manufacturing steel plate for ultra-high-strength linepipe having excellent low-

temperature toughness comprising the steps of:

heating slabs consisting of:

C : 0.03 to 0.07 mass%

Si : not more than 0.6 mass%

5 Mn : 1.5 to 2.5 mass%

P : not more than 0.015 mass%

S : not more than 0.003 mass%

Mo : 0.15 to 0.60 mass%

Nb : 0.01 to 0.10 mass%

10 Ti : 0.005 to 0.030 mass%

Al : not more than 0.10 mass%

B : 3 ppm to 0.0025 mass%

and, one or more of:

Ni : 0.1 to 1.5 mass%

15 N : 0.001 to 0.006 mass%

V : not more than 0.10 mass%

Cu : not more than 1.0 mass%

Cr : not more than 1.0 mass%

Ca : not more than 0.01 mass%

20 REM : not more than 0.02 mass%

Mg : not more than 0.006 mass%

and the remainder consisting of iron and unavoidable impurities and having the value P defined below being between 2.5 and 4.0 and between 1000 and 1250 °C,

25 rough rolling in a recrystallized region,

30

35

rolling in an unrecrystallization austenitic region at 900  $^{\circ}$ C or below with a cumulative rolling reduction of not less than 75% and, then,

applying accelerated cooling from the austenitic region so that the center of plate thickness cools to 500 °C or below at a rate of 1 to 10 °C/sec.,

$$P = 2.7C + 0.4Si + Mn + 0.8Cr + 0.45(Ni + Cu) + 2Mo$$

wherein the symbols of elements designate the mass% of the individual elements.

17. A method for manufacturing steel plate for

ultra-high-strength linepipe having excellent lowtemperature toughness described in claim 15 or 16, in which slabs also contain

N : 0.001 to 0.006 mass.

5

10

15

20

25

30

35

- 18. A method for manufacturing steel plate for ultra-high-strength linepipe having excellent low-temperature toughness described in 17, in which the relationship Ti 3.4 N > 0 is satisfied (wherein the symbols of elements designate the mass% of the individual elements).
- 19. A method for manufacturing ultra-high-strength linepipe having excellent low-temperature toughness comprising the steps of:

forming a steel plate manufactured by the methods for manufacturing ultra-high-strength steel plate having excellent low-temperature toughness described in any of claims 15 to 18 into a pipe form so that the rolling direction of the steel plate agrees with the longitudinal direction of a pipe to be manufactured, and

forming a pipe by seam-welding together the edges thereof.

20. A method for manufacturing ultra-high-strength linepipe having excellent low-temperature toughness comprising the steps of:

forming a steel plate manufactured by the methods for manufacturing ultra-high-strength steel plate having excellent low-temperature toughness described in any of claims 15 to 18 into a pipe form by the UO process so that the rolling direction of the steel plate agrees with the longitudinal direction of a pipe to be manufactured,

forming a pipe by joining together the edges thereof by applying submerged-arc welding from both inside and outside, and

expanding the welded pipe.

21. A method for manufacturing ultra-high-strength linepipe having excellent low-temperature toughness comprising the steps of:

heating slabs consisting of: С : 0.03 to 0.07 mass% Si : not more than 0.6 mass% : 1.5 to 2.5 mass% Mn 5 Р : not more than 0.015 mass% S : not more than 0.003 mass% : 0.1 to 1.5 mass% Νi : 0.15 to 0.60 mass% Mo Nb : 0.01 to 0.10 mass% 10 Тi : 0.005 to 0.030 mass% : not more than 0.06 mass% Al and, one or more of: : not more than 0.0025 mass% В : 0.001 to 0.006 mass% N 15 V : not more than 0.10 mass% : not more than 1.0 mass% Cu Cr : not more than 1.0 mass% : not more than 0.01 mass% Ca : not more than 0.02 mass% REM 20 : not more than 0.006 mass% Μa and the remainder consisting of iron and unavoidable impurities and having the value P defined below being between 2.5 and 4.0 and between 1000 and 1250 °C, rough rolling in a recrystallized region, 25 rolling in an unrecrystallization austenitic region at 900 °C or below with a cumulative rolling reduction of not less than 75%, applying accelerated cooling from the austenitic region so that the center of plate thickness cools to 500 30 °C or below at a rate of 1 to 10 °C/sec., forming the steel plate thus manufactured into a pipe form so that the rolling direction of the steel plate agrees with the longitudinal direction of a pipe to be manufactured, and 35 forming a pipe by welding together the edges

thereof.

. P = 2.7C + 0.4Si + Mn + 0.8Cr + 0.45(Ni + Cu) +  $(1 + \beta)$ Mo - 1+ $\beta$ 

where  $\beta$  = 1 when B  $\geq$  3 ppm and  $\beta$  = 0 when B < 3 ppm wherein the symbols of elements designate the mass% of the individual elements.

5

10

15

22. A method for manufacturing ultra-high-strength linepipe having excellent low-temperature toughness described in claim 21, which furthermore comprising the steps of:

forming the steel plate subjected to accelerated cooling into a pipe form by the UO process so that the rolling direction of the steel plate agrees with the longitudinal direction of a pipe to be manufactured,

joining the edges thereof together by applying submerged-arc welding from both inside and outside, and expanding the welded pipe.